Lada A. Adamic and Bernardo A. Huberman

Technical comment to ‘Emergence of Scaling in Random Networks’, Vol. **286** 15 October 1999, pp. 509-512.

A recent paper by Barabasi and Albert ‘Emergence of Scaling in Random Networks’, Vol. **286** 15 October 1999, pp. 509-512 , proposes an improved version of the Erdos Renyi theory of random networks in order to account for the scaling properties of a number of systems, including the link structure of the World Wide Web. We wish to point out that the theory they present is inconsistent with empirically observed properties of the web link structure.

Barabasi and Albert write: “Because of the preferential attachment, a vertex that acquires more connections than another one will increase its connectivity at a higher rate; thus, an initial difference in the connectivity between two vertices will increase further as the network grows... Thus older [] vertices increase their connectivity at the expense of the younger []ones, leading over time to some vertices that are highly connected, a “rich-get-richer” phenomenon.” This is demonstrated clearly in Fig 2c) in the original paper.

It is this prediction of the Barabasi-Albert (BA) model that renders it unable to account for the power law distribution of links in the WWW (Fig. 1b in the original paper). We studied a crawl of 260,000 sites, where each site is a separate domain name. We counted how many links the sites received from other sites. As for pages, the distribution of links among sites, shown in Fig. 1, is power law. Next we queried the Internic database (1) for the date the site was originally registered. Whereas the BA model predicts that older sites not only have an advantage for having more time to acquire links, but gather links at a faster rate than newer sites, our data, shown in Fig. 2, demonstrates that, in fact, there is no correlation between the age of a site and the number of links it has.

The absence of correlation between age and the number of links is hardly surprising. All sites are not created equal. A site with very popular content, which appears in 1999, will soon have more links than a bland site created in 1993. It is likely that the rate of acquisition of new links is proportional to the number of links the site has already. After all, the more links a site has, the more visible it becomes, the more new links it will get. However, there should be an additional proportionality factor, or growth rate, which varies from site to site.

Our recently proposed theory (2), which accounts for the power law distribution in the number of pages per site, can also be applied to the number of links a site receives. In this model, at each time step the number of new links a site receives is a random fraction of the number of links the site already has. New sites appear at an exponential rate and each has a different growth rate. This model yields scatter plots similar to the one shown in Fig. 2 and can produce any exponent $\gamma > 1$.

References:

1. http://www.networksolutions.com
2. B.A. Huberman and L.A. Adamic, *Nature* **401**, 131 (1999).

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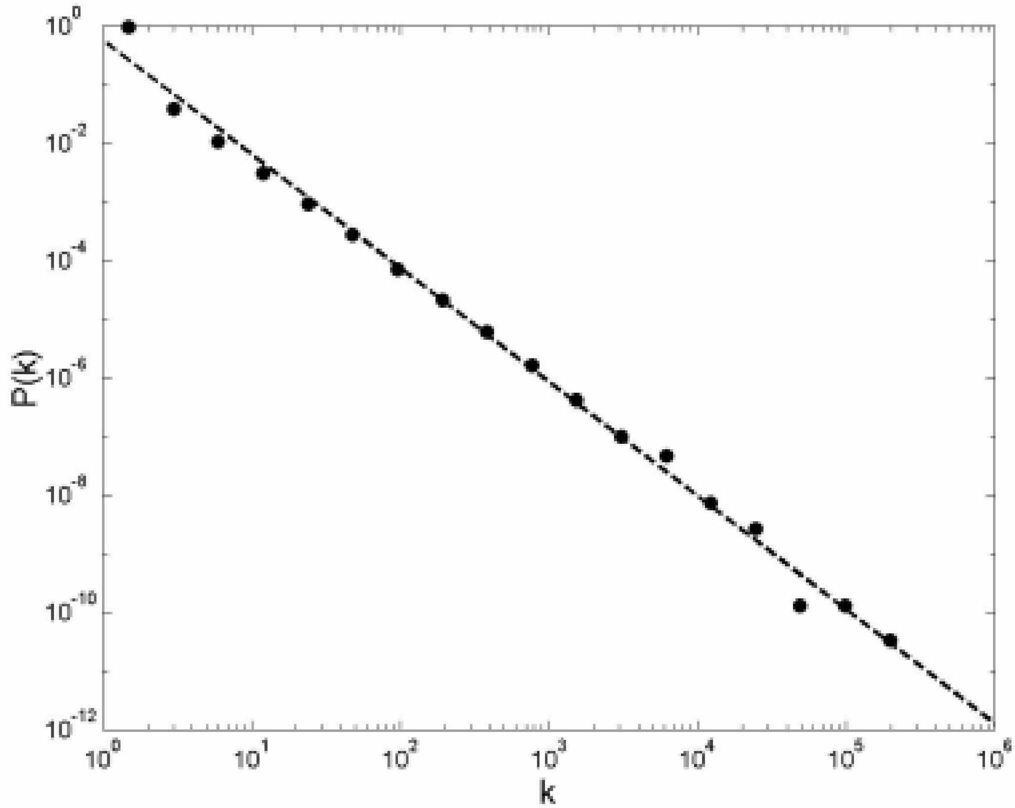

Fig. 1 The distribution function for the number of links, k, to web sites (from crawl in spring 1997). The dashed line has slope $\gamma = 1.94$.

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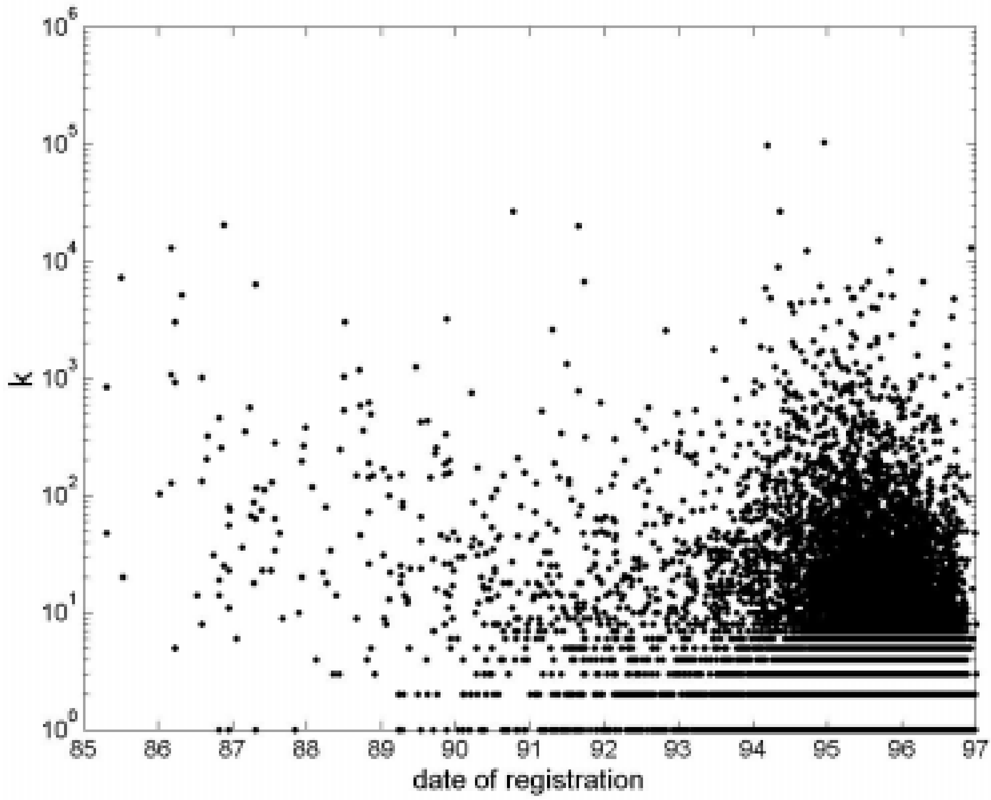

Fig. 2 Scatter plot of the number of links, *k*, vs. age for 120,000 sites. The correlation coefficient is 0.03.